

Performance Evaluation of the Approaches and Algorithms for Hamburg Airport Operations

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In today's commercial aviation system, airport operation remains as one critical component that has great impact on system performance. According to a 2013 comparison of Air Traffic Management (ATM) operational performance by EUROCONTROL and FAA [1], airports contribute to 56% and 86% of total Air Traffic Flow Management (ATFM) delay in Europe and US, respectively. Insufficient capacity, huge operation uncertainties, and lack of coordination and information sharing among stakeholders and service providers lead to excessive taxi delay and missed opportunities of resource utilization. DLR and NASA have been independently developing and testing their own concepts and prototype tools to address the challenges in surface ATM. Although these concepts and tools have been tested individually in European and US airports [2,3], they have never been compared nor analyzed side-by-side. To fill the gap, DLR and NASA recently conducted a collaborative research in surface ATM.

This paper describes the performance evaluation of the approaches and algorithms developed by DLR and NASA that enables trajectory-based surface operations, thus improving efficiency and predictability. The algorithms were applied to a common airport (Hamburg Airport). It starts with a comparison of current day operations in Europe and U.S. airports, followed by description of the concepts and tools developed by DLR and NASA independently with respect to the two different operational environments, and finally comparison of the simulation results using common scenarios.

DLR has implemented a Departure Management System (DMAN), called Controller Assistance for Departure Optimization (CADEO) and a Surface Management System (SMAN) called TRACC (Taxi Routing for Aircraft: Creation and Controlling) [2]. CADEO is a controller tool that optimizes the departure takeoff sequence and calculates the Target Take-off Times (TTOTs) and was already tested at several European airports. TRACC generates, controls and maintains conflict-free time-based trajectories for all aircraft ground movements and calculates the Target Start-up Approval Time (TSAT). Each trajectory includes speed controls/profiles that can be adapted at flight deck or unmanned vehicle.

NASA's research team has adopted a concept of Spot and Runway Departure Advisory (SARDA). Its implementation, as a decision-support tool for controllers, consists of a runway optimizer that calculates optimal runway departure sequence, a spot scheduler to assist controller to meter aircraft into movement area, and a taxi time predictor [3]. In a recent study, the SARDA concept has been adapted to Charlotte airport (CLT) ramp operations to provide tactical gate pushback advisory. The SARDA tool has been designed primarily for human-in-the-loop (HITL) study and ready for field test. Its components are also configured and coupled in fast-time simulation study using NASA's Surface Operation Simulator and Scheduler (SOSS).

The main work described in the paper is devoted to the performance comparison and analysis based on simulations. First, two independent simulations are conducted at Hamburg airport, using historical flight data: one by NASA team using SARDA and SOSS tools and one by DLR team using CADEO and TRACC with the NLR ATM Research Simulator (NARSIM). To ensure valid and meaningful comparison, the two teams jointly developed a set of common performance metrics. The measurements of the metrics use a timeframe that consists of common data events such as pushback, wheels-on in both tools.

The simulation results are evaluated side-by-side with the common metrics to answer the questions such as what are the common merits of the two, and what are the particular performance areas where one is more effective? The initial results show that the trajectory-based operations with integrated departure and surface (taxiing) management, in both DLR and NASA's tools consistently show benefits in efficiency area, such as reducing taxi times. The conflict-free taxiing operation supported by DLR's TRACC helps improve performance in predictability area. Detailed numbers and suggestions for further collaboration will be provided.

In addition, both teams consider the trajectory-based surface operation concept [3] a critical technology advance in not only addressing the current surface traffic management problems, but also having potential applications in operations of unmanned vehicles on airport surface via autonomous towing like TaxiBot and even Unmanned Aerospace Systems (UAS).

References:

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3. Nikolai Okuniek, A Concept of Operation for Trajectory-based Taxi Operations, abstract accepted by ATIO 2016